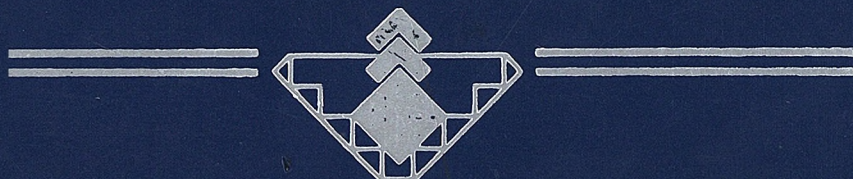


QUANTUM ELECTRONICS

THIRD EDITION



AMNON YARIV

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Third Edition

Amnon Yariv

California Institute of Technology



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To The Memory of My Father

Preface

The thirteen years that have intervened since the appearance of the second edition of this book have witnessed some important developments in the field of lasers and quantum electronics. Foremost among them are: phase-conjugate optics and its myriad applications, the long wavelength quaternary semiconductor laser, and the deepened understanding of the physics of semiconductor lasers—especially that applying to their current modulation and limiting linewidth, laser arrays and the related concept of supermodes, quantum well semiconductor lasers, the role of phase amplitude coupling in laser noise, and free-electron lasers. The present edition retains nearly all the material of the second edition. There are four new chapters on semiconductor lasers, quantum well lasers, free-electron lasers, and phase-conjugate optics. In addition, the chapters on laser noise and third-order nonlinear effects have been extensively revised.

I benefited from teaching the material and from feedback at Caltech by colleagues and students who aided me in tightening and improving numerous points throughout the book. To these individuals special thanks are due. I am grateful to my administrative assistant, Jana Mercado, for her assistance in preparing this edition. I also take pleasure in thanking the talented group of students and ex-students, especially K. Lau, K. Vahala, C. Harder, T. Koch, M. Cronin-Golomb, S. Kwong, and the late C. Lindsey, whose research efforts are responsible for much of the new material added to this edition. The material on quantum well lasers benefited greatly from my association with Y. Arakawa while David Crouch contributed a major part of the treatment of squeezed states.

Pasadena, California
September 1987

Amnon Yariv

Preface to the Second Edition

This textbook introduces the main principles involved in the study and practice of quantum electronics, which include the theory of laser oscillators, a wide range of optical phenomena, and devices that owe their existence to the intense and coherent optical fields made possible by the laser.

The emphasis is almost exclusively on fundamental principles. An attempt is made, however, to bridge the gap between theory and practice through the use of numerical examples based on real situations.

Approximately one-half of this edition is new. In addition, a number of topics related to microwave phenomena and magnetic resonance were omitted. The major changes are as follows.

1. The addition of treatments on Gaussian beam propagation in lenslike media, optical resonators, density matrix formulation of the interaction of light and matter, theory of laser oscillation, Van der Pol noise analysis of lasers, dye lasers, amplification in vibrational-rotational transitions, double heterojunction lasers, mode locking in homogeneously broadened lasers, Q-switching, saturated amplifiers and amplification of spontaneous emission, acoustooptic interactions, self-induced transparency, photon echoes, spontaneous parametric fluorescence, distributed feedback lasers, and mode coupling in dielectric waveguides.

2. The deletion of chapters dealing with microwave masers, magnetism, magnetic resonance, and microwave parametric oscillators.

3. An exclusive use of the meter-kilogram-second (MKS) unit system.

This text is primarily for the graduate student in physics and applied physics. The latter category often includes students in departments of electrical engineering and material science.

The typical Caltech student taking the course from which this book was developed has a background of a one-year rigorous course in quantum mechanics and one course in electromagnetic theory. These are courses taken by the more advanced students in their senior year but often in the first year of graduate school. A good familiarity with these two topics is assumed, although most of the prerequisite background material is included here.

The book can be used as a basis for a one-year course in quantum electronics or, alternatively, for these one-semester courses:

1. Lasers: Chapters 5–13.
2. Nonlinear Optical Effects and Stimulated Scattering Phenomena: Chapters 14 (part dealing with acoustooptics), 15–18.
3. Optical Modes and Propagation Phenomena: Chapters 5–7, 14, 19.

Course 1 makes heavy use of quantum mechanics. In course 2 quantum mechanics is needed only in Chapter 15, while in course 3 it is not used at all. An electromagnetic background is needed in all three courses.

I apologize to any of my colleagues whose work has not been acknowledged or adequately represented in this book. Since this is primarily a textbook, the material was chosen mainly because of pedagogic considerations rather than chronological precedence.

I thank Ruth Stratton and Dian Rapchak for typing and proofreading the original manuscript and Paula Samazan for assisting with the references.

Thanks are due to Dr. Jack Comly who made important contributions to Chapters 15 and 18 and to Mr. H. W. Yen who has gone over the whole manuscript rederiving the results and checking the internal consistency of the text.

Amnon Yariv

About the Author

Amnon Yariv, a native of Israel, received his higher education at the University of California at Berkeley. After four years at the Bell Telephone Laboratories, he joined the California Institute of Technology (Caltech) where he is the Thomas G. Myers Professor of Electrical Engineering and Applied Physics. At Caltech he studies with a team of doctoral students and postdoctoral fellows, a number of research topics in laser physics, nonlinear optics, and optoelectronics. Some of his major contributions include the invention and co-invention of the fields of integrated optoelectronic circuits, phase conjugate optics, and the authoring of the first papers on the theory of mode locking and nonlinear quantum optics. Dr. Yariv is also the founder and chairman of the board of ORTEL Corporation, a semiconductor laser company in Alhambra, California.

When not working, which is rare, he spends time with his family (wife—Fran and three daughters) as well as with a piano, a tennis racket, and a windsurfer.

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